国家发展和改革委员会
能源研究所
Energy Reform Institute NDRC.P.R.C

CNREC
国家可再生能源中心
CHINA NATIONAL RENEWABLE ENERGY CENTRE

CIFF
CHILDREN'S INVESTMENT FUND FOUNDATION

China Renewable Energy Outlook

2017

Energy Research Institute of Academy of Macroeconomic Research/NDRC

China National Renewable Energy Centre

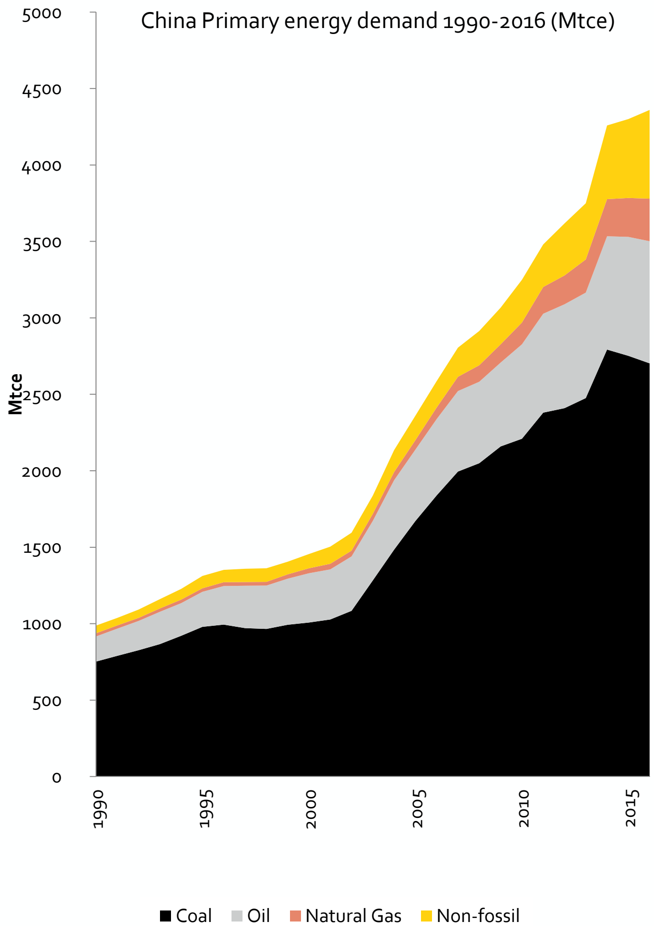
Wang Zhongying, vice director ERI, director CNREC

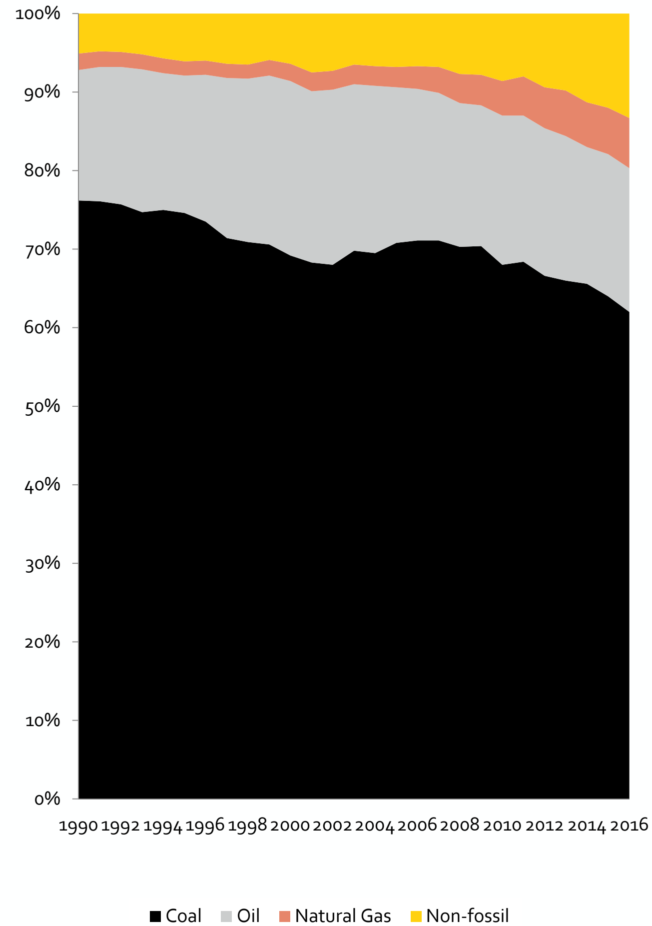
CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

The Chinese energy system - last 25 years development

Tremendous growth in energy consumption – coal dominates

- China's energy consumption has grown from **572 Mtce** in 1978 to **4360 Mtce** in 2016
- Coal share always **higher than 65%** until 2015
- Severe consequences for the environment – air pollution, water, soil, CO_2 emission

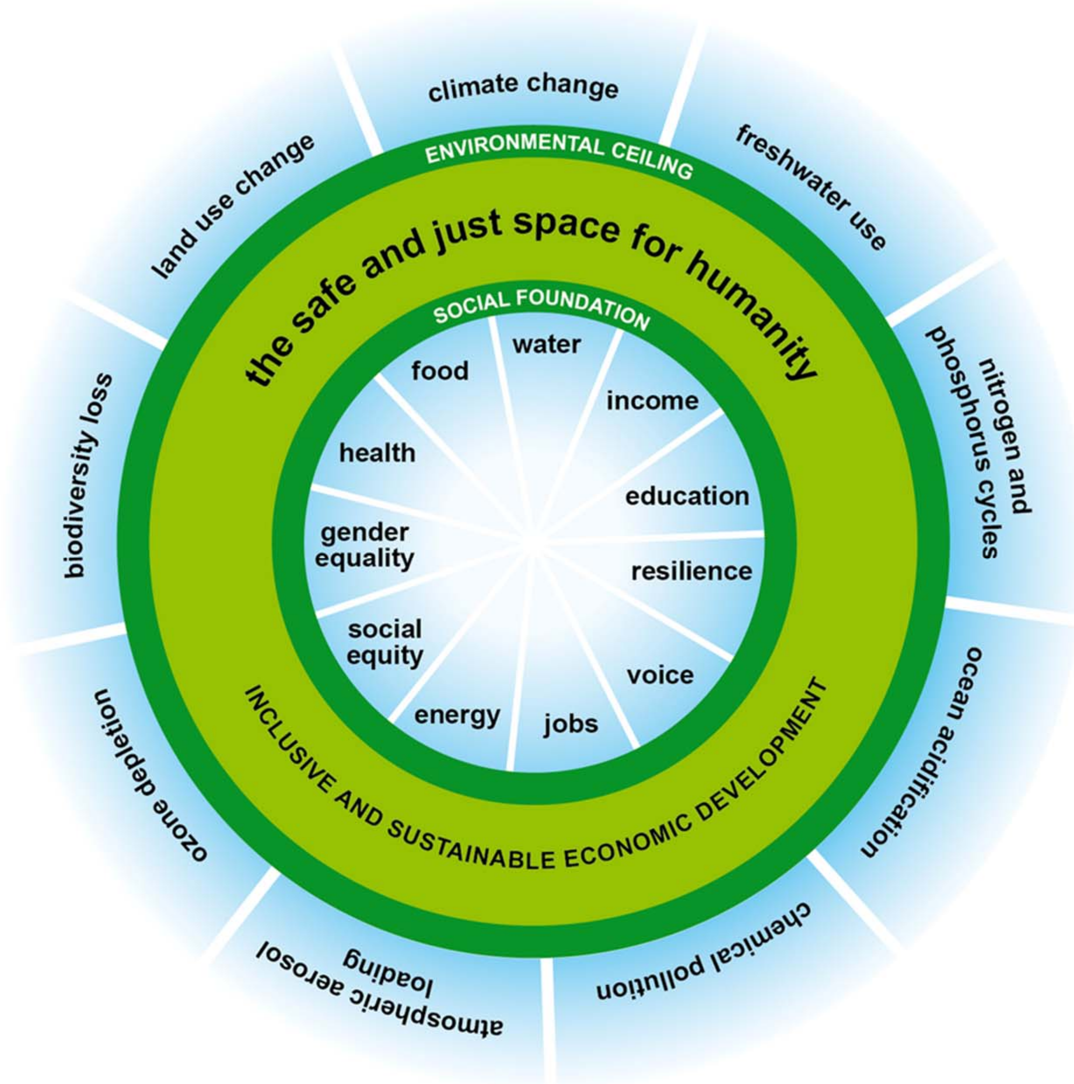




Economic and social development within ecological boundaries

"It is important to protect the environment while pursuing economic and social progress so as to achieve harmony between man and nature and between man and society"

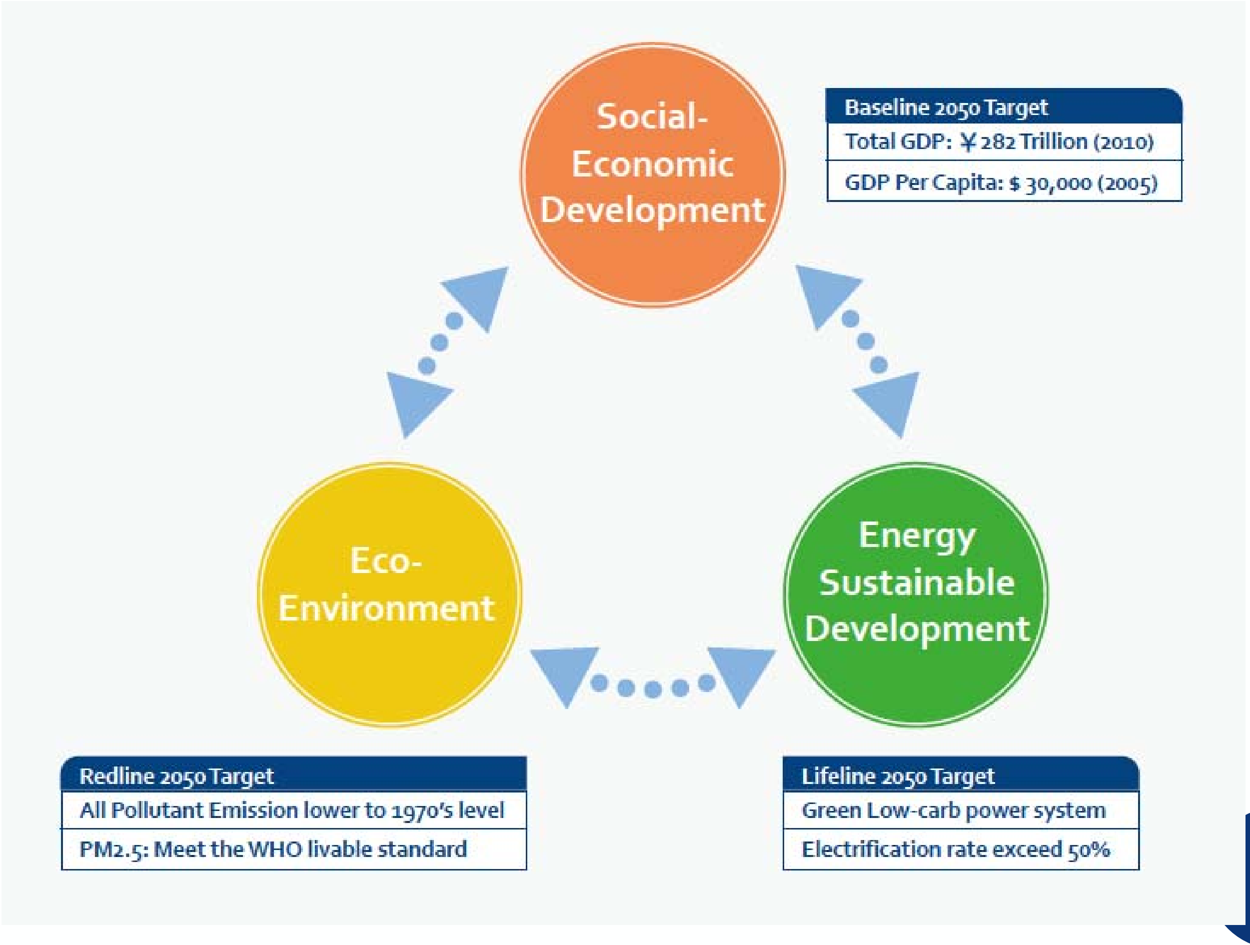
President Xi Jinping, World Economic Forum, Davos, January 2017



Source: The doughnut economy

"The Three Lines" development concept

- The baseline – **the socioeconomic development targets** – must be reached – **282 Trillion RMB** in 2050
- The red line – **the ecological boundaries** - cannot be overstepped
- The lifeline – **the sustainable energy development** – is the instrument to reach the baseline without overstepping the red line



CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

CREO 2017 APPROACH

CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

The two main research questions in CREO 2017

What is the development trend for the Chinese energy system, if the policy already stated is vigorously implemented?

How can China comply with the Paris agreement using the Chinese overall strategies and priorities?

Our approach

Scenarios for the whole Chinese energy system

Bottom-up models for the energy demand and for the power system

Detailed power system model simulating the current dispatch rules as well as an efficient wholesale market dispatch

Use scenario analyses as basis for policy strategy research and policy recommendations

Two main scenarios

Stated Policies Scenario

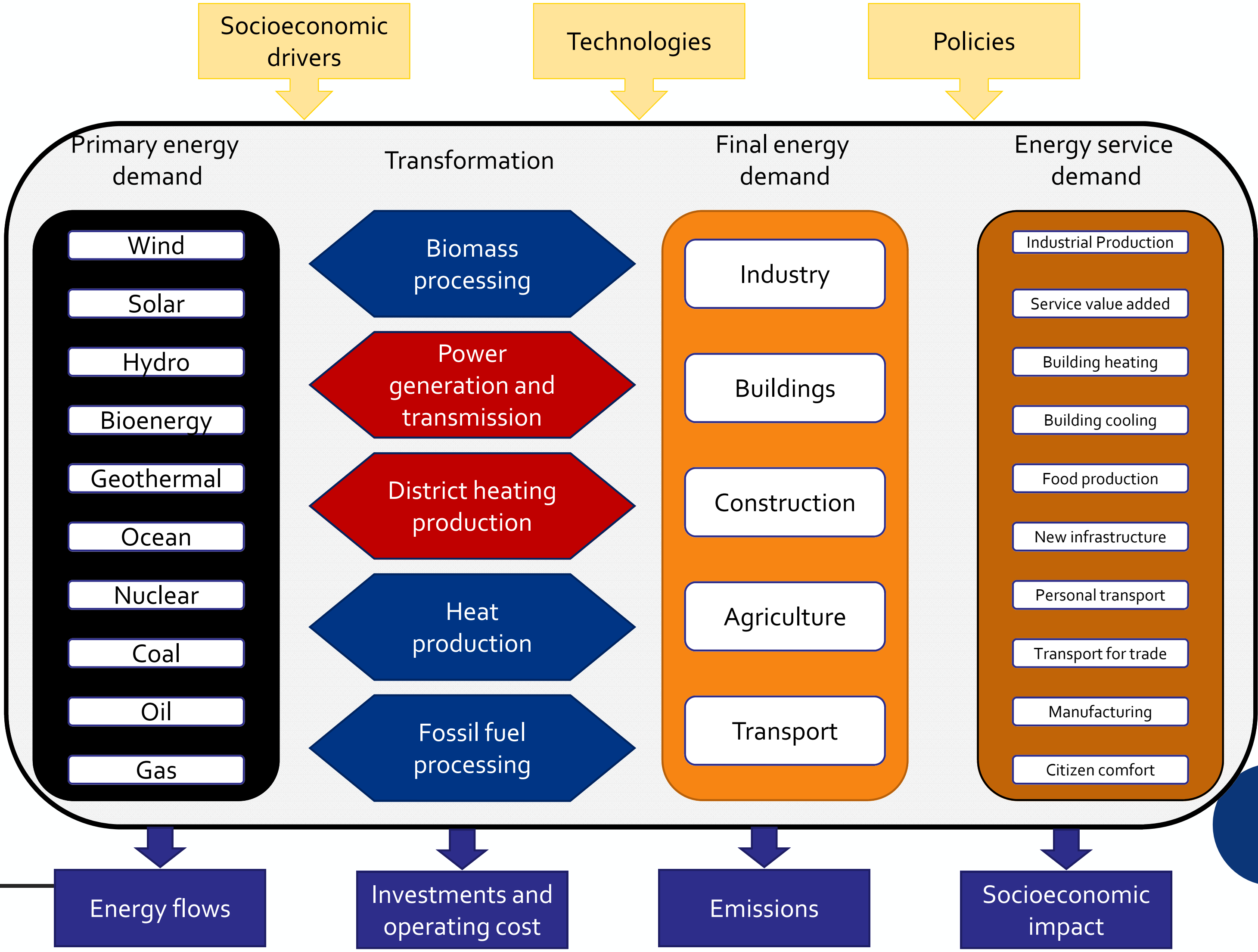
Impact of a strong implementation of the current and planned policy

Below 2 °C Scenario

Strong CO_2 constraints as contribution to compliance with the Paris agreement

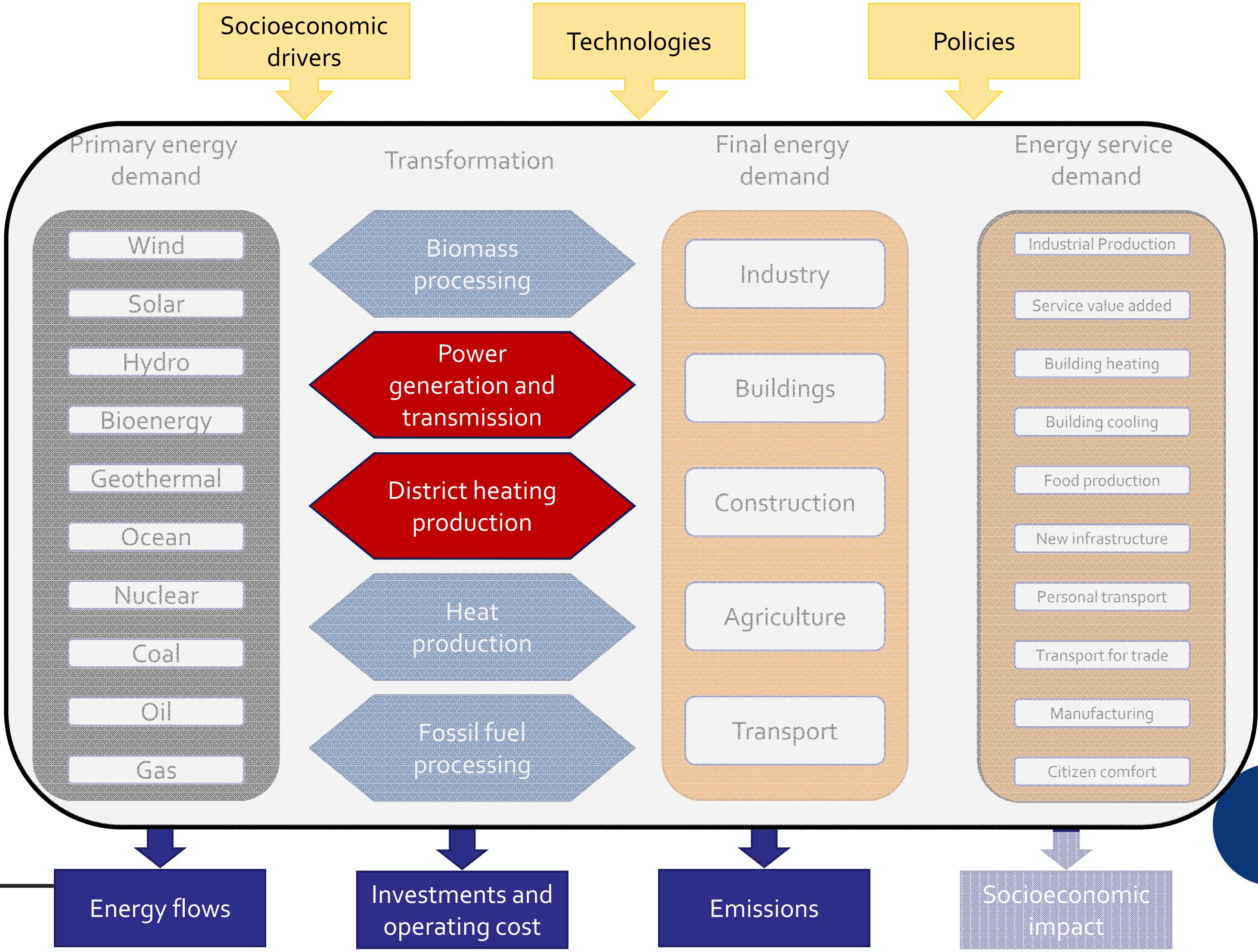
Energy system modelling

The scenarios are modelled in the CNREC modelling suite, covering energy supply, energy transformation and end-use sectors.



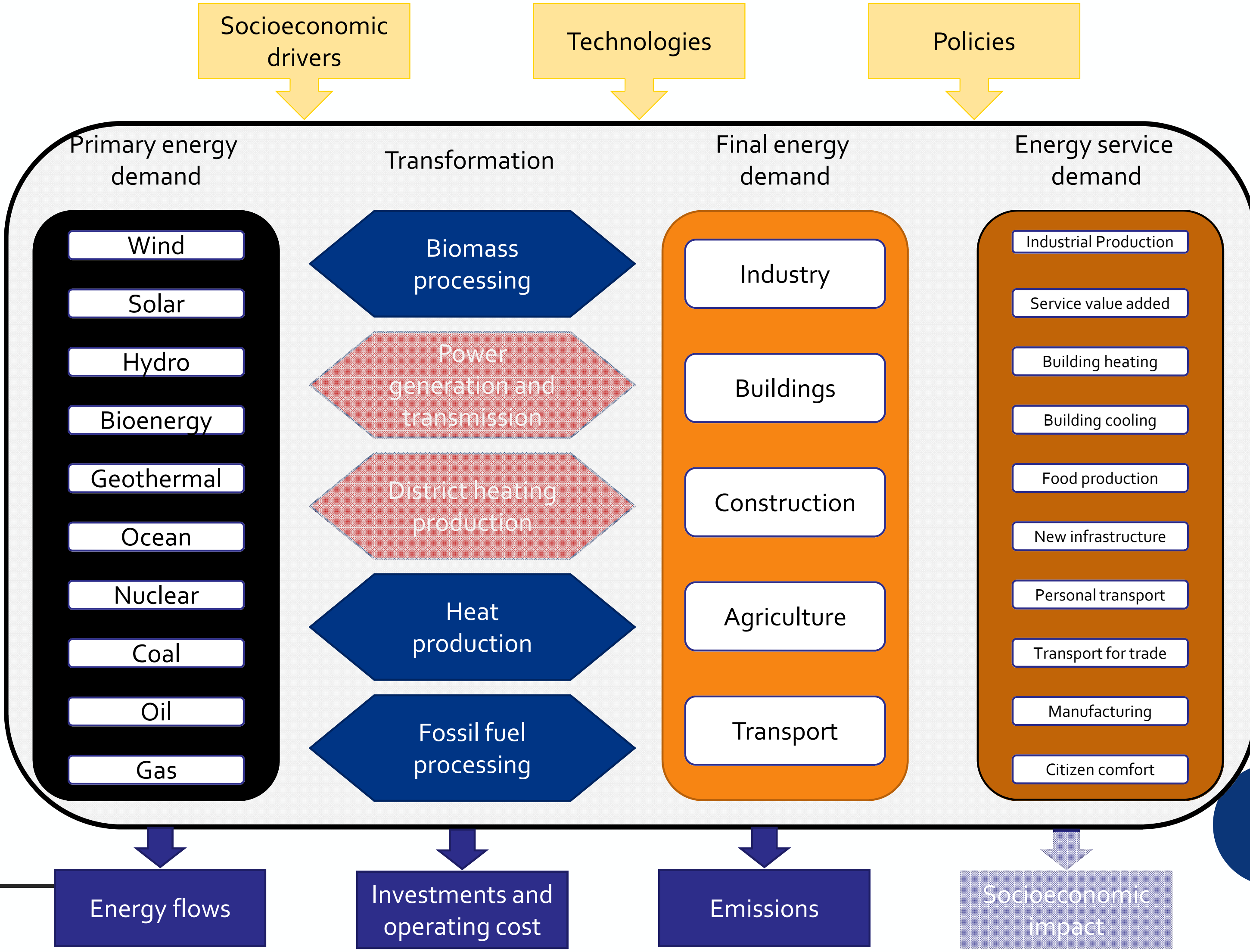
EDO model

The production of power and district heating is modelled in the bottom-up, least-cost optimisation model EDO in order to reflect cost effective integration of variable energy production.



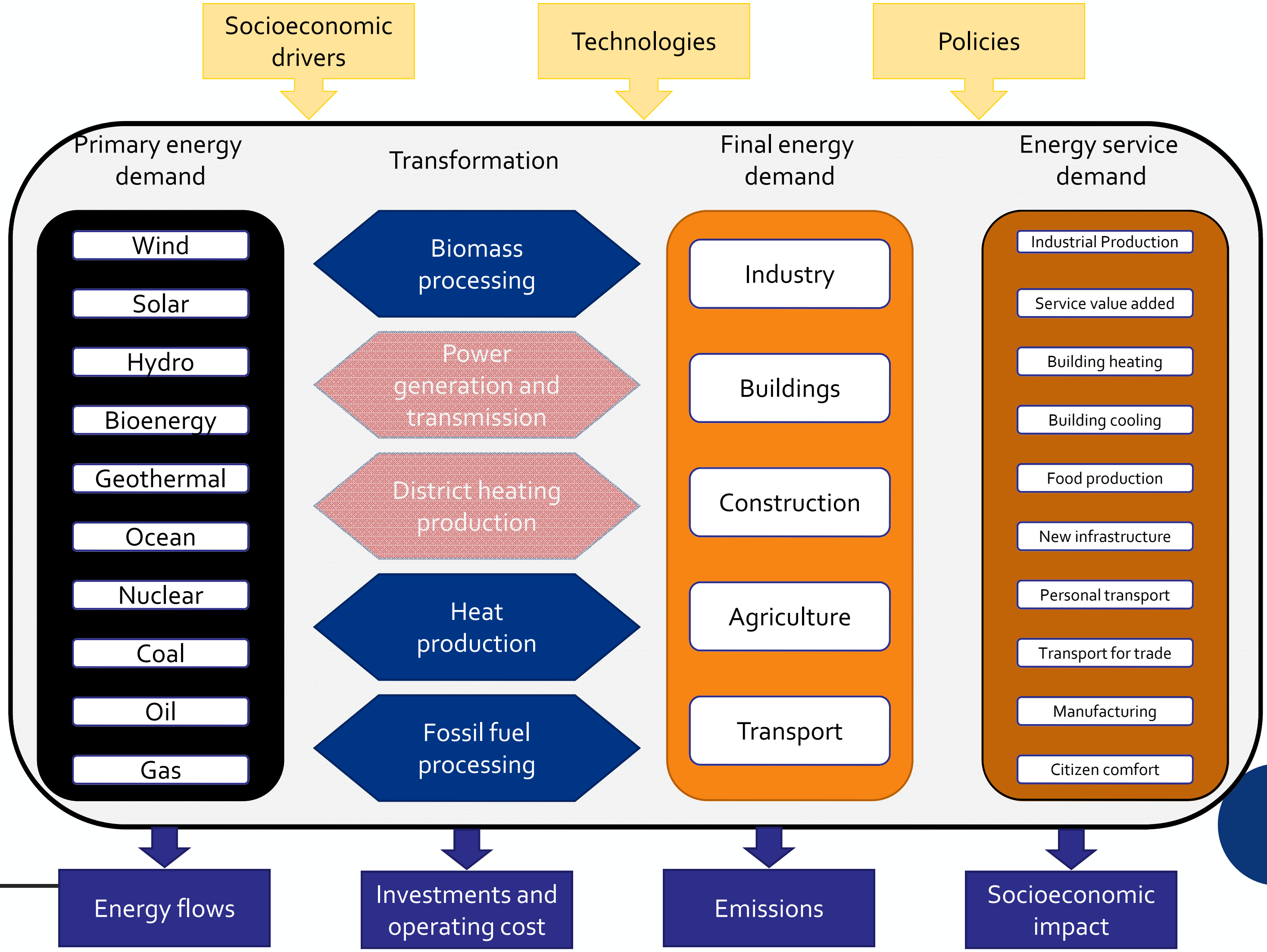
END-USE model

The end-use sectors and the other energy transformation is modelled in END-USE based on the LEAP modelling tool and a bottom-up approach



CGE model

The socioeconomic impact of the transformation of the energy system is modelled in the CGE model – a computerised general equilibrium model with special focus on the energy and RE sector



KEY DRIVERS FOR ENERGY TRANSITION

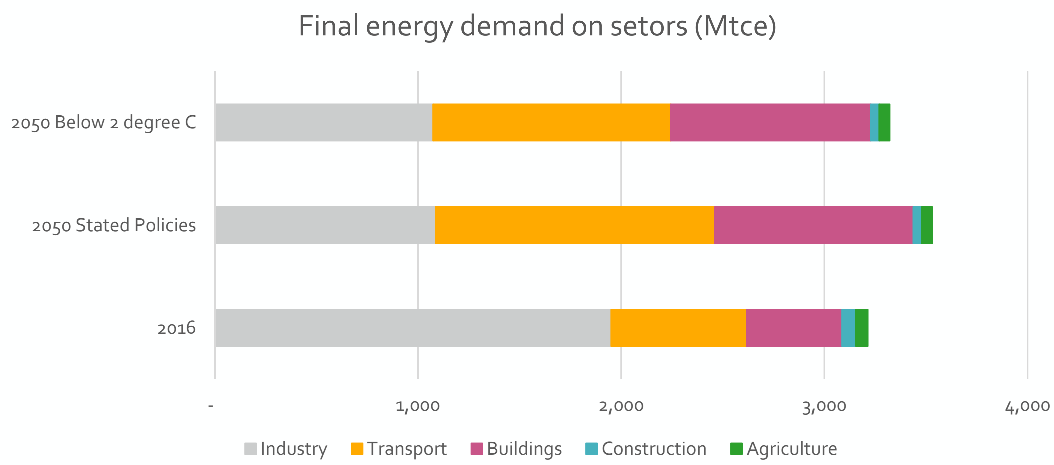
CHINA NATIONAL RENEWABLE ENERGY CENTRE

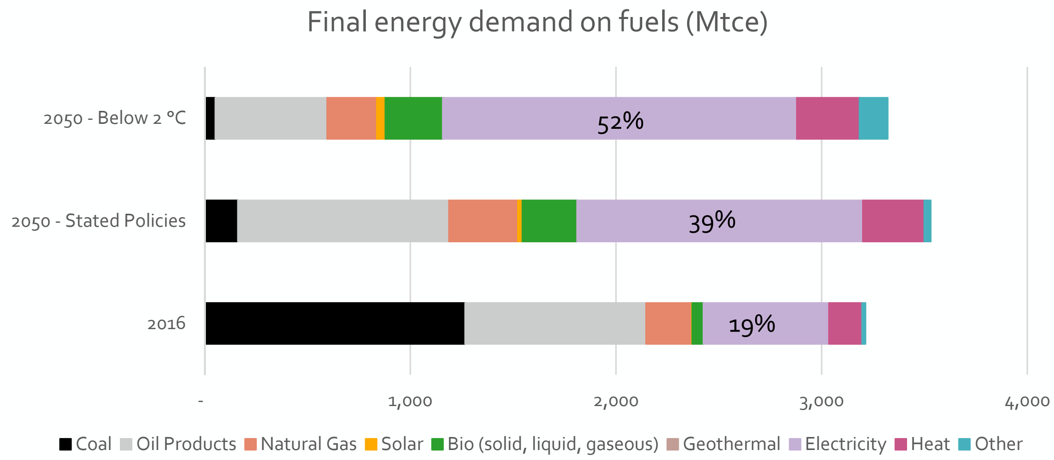
Key drivers for energy transition

- Energy efficiency in the end-use sectors
- Electrification as means to energy efficiency and fossil-fuel reduction
- Actively push RE energy costs down through scale-up and innovative incentives
- Create a level playing-field for RE through carbon pricing
- Use power markets as the major tool for cost-efficient energy transformation

End-use transition –
similar trends in both scenarios

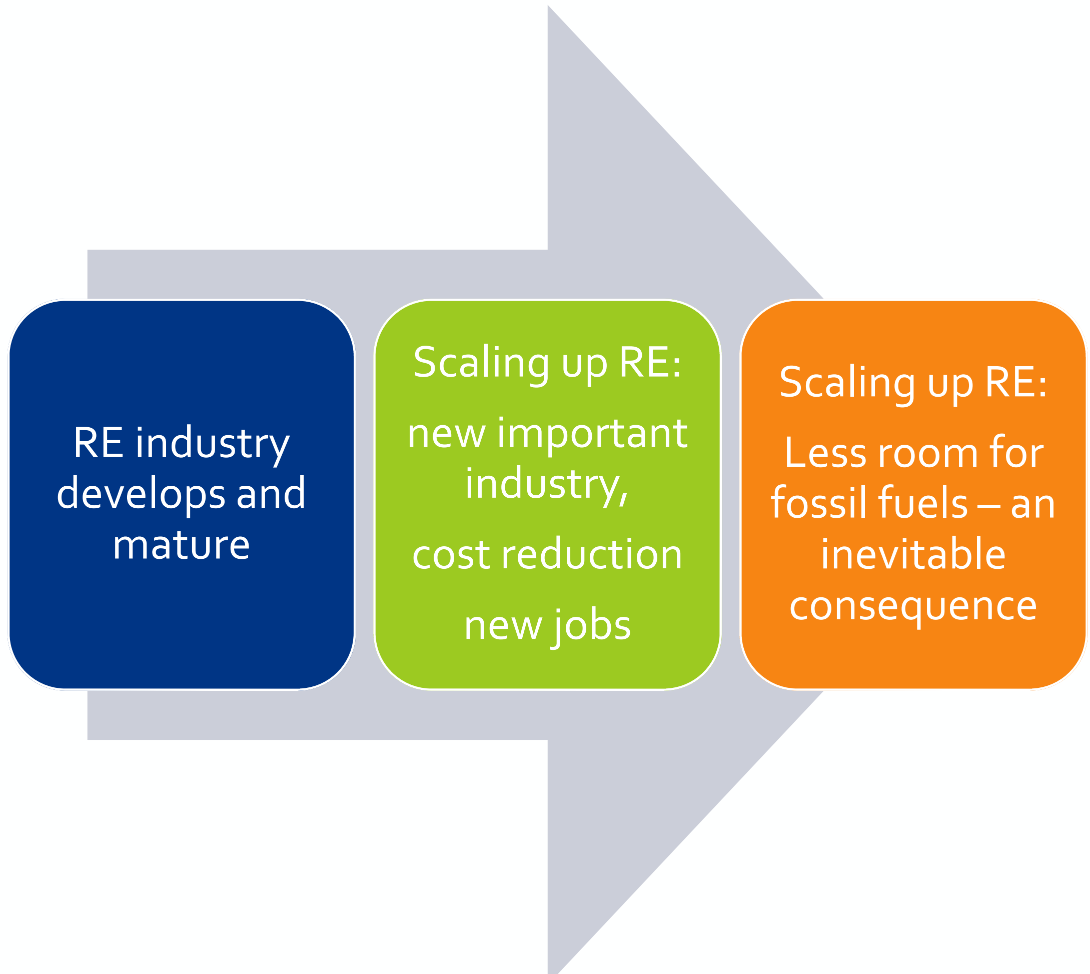
- **Energy efficiency improves**
  - Only **slight increase** in final energy consumption despite economic growth – due to energy efficiency measures and electrification
- **Structural changes in consumption**
  - **Industry** energy use **decline**, while transport and building sectors increase energy consumption
- From coal and oil to **electricity:**
  - From 19% in 2016 to 39% in Stated Policies in 2050
  - Below 2 ° C even higher: 52% in 2050





RE cost reduction by scaling up the deployment of renewables

The RE industry becomes an important part of China's economy



Fossil fuel prices must reflect the real cost

CO_2 price in the ETS market

- Sets a minimum cost for CO_2 emission in the scenario calculations

CO_2 constraints for the energy system

- Forces fossil fuels out of the energy system earlier – gives higher CO_2 costs if the constraints are reflected in the ETS market
- Does not impact the transition in the Stated Policies Scenario

Minimum cost for CO_2 emission in the ETS market

	2017	2020	2030	2040	2050
Stated Policies	30	50	100	100	100
Below 2 °C	30	50	100	200	200

CO_2 emission constraints

Scenario	Parameter	Year 2020	Year 2030	Year 2050
Stated Policies Scenario	Carbon Intensity	40-45%	60-65%	-
Below 2 °C Scenario	Carbon cap (Mt CO_2)	9,000	8,000	3,000

CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

Power market development

- from local to national markets

Generation rights phase-out

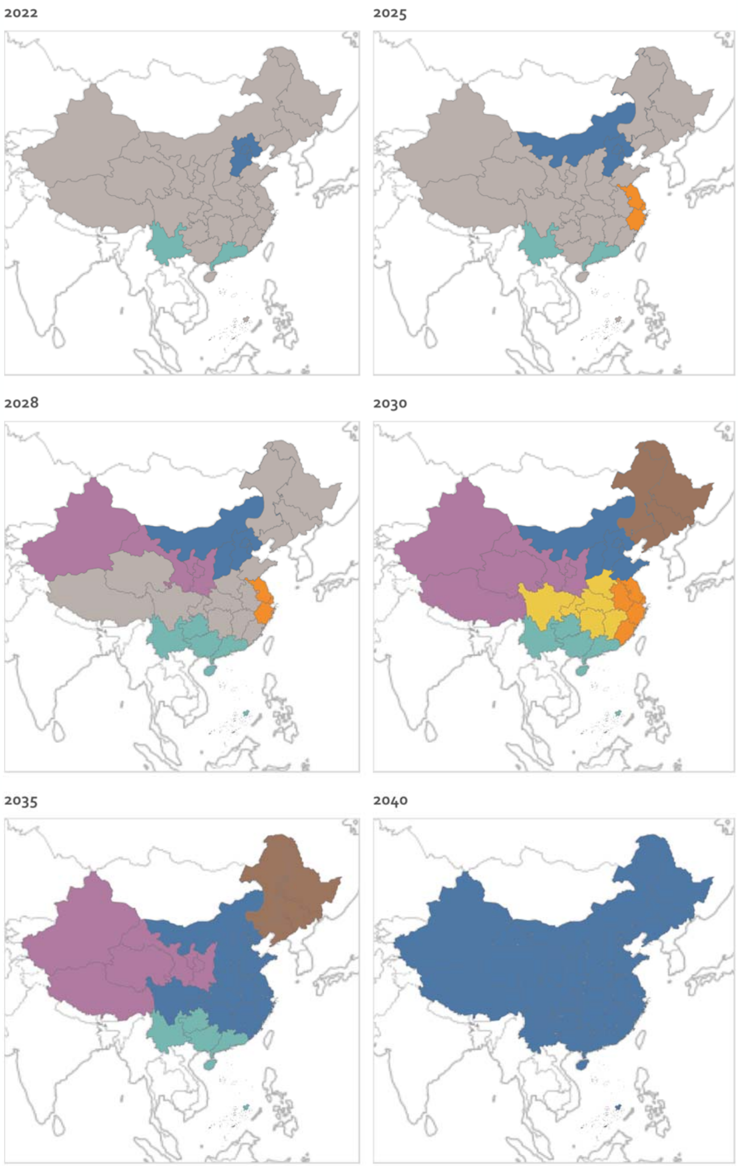
- Minimum full annual load hours reduced to zero towards 2025
- Merit-order dispatch based on spot markets

Interconnection of provincial markets

- First regional markets in 2022
- Full integration from 2040

Market price stimulating flexible operation and new technologies

- Incentives for flexible dispatch of thermal power plants and interconnectors
- Demand side response and smart charging of EVs gradually introduced
- Electric boilers, heat pumps and heat storages



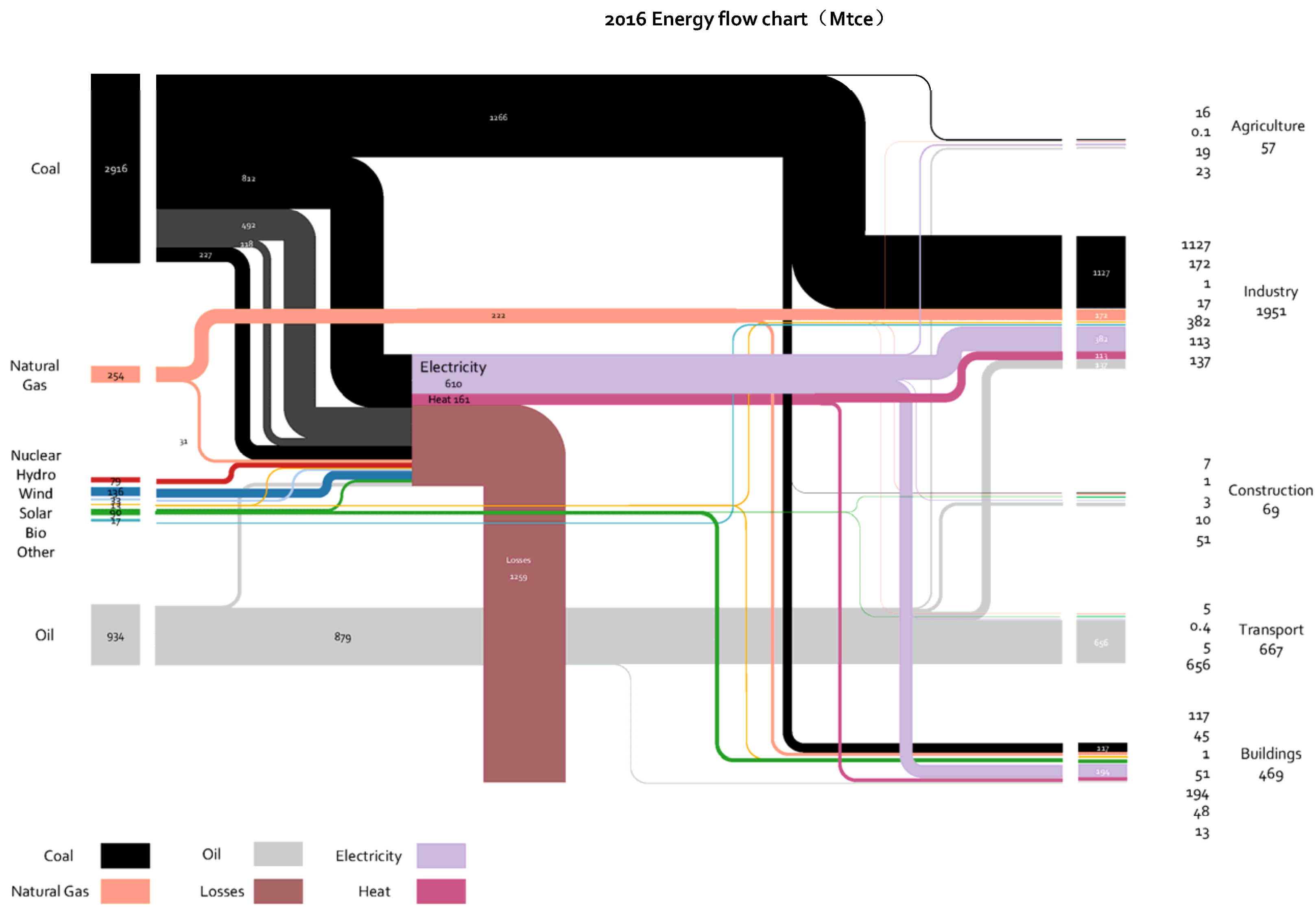
SCENARIO RESULTS

CNREC

CHINA NATIONAL RENEWABLE ENERGY CENTRE

Today's energy system

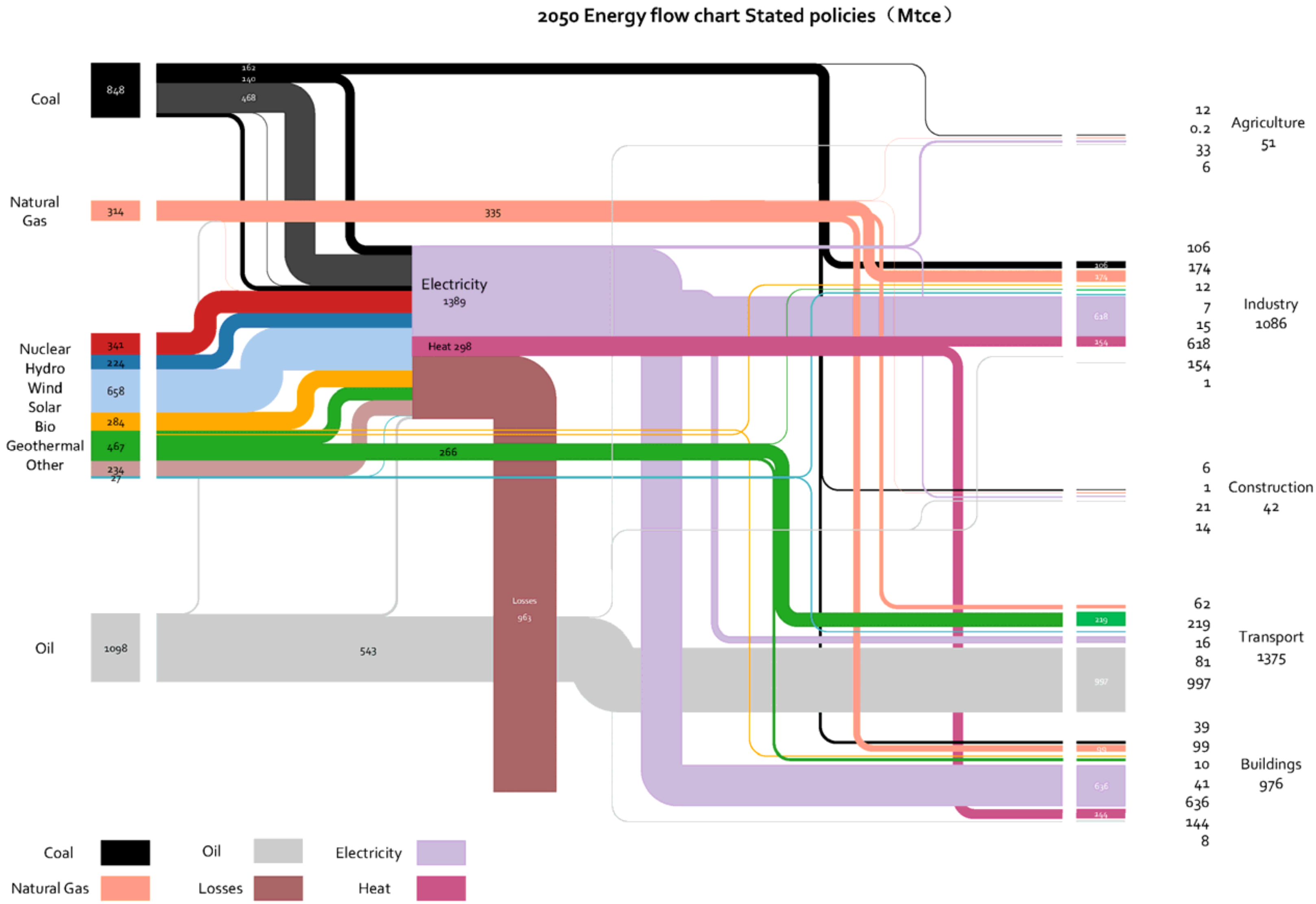
From todays energy energy system mainly based on coal and oil



CNREC CHINA NATIONAL RENEWABLE ENERGY CENTRE

2050 Stated Policies

To a system with a high share of RE and electrification of the end-use sector



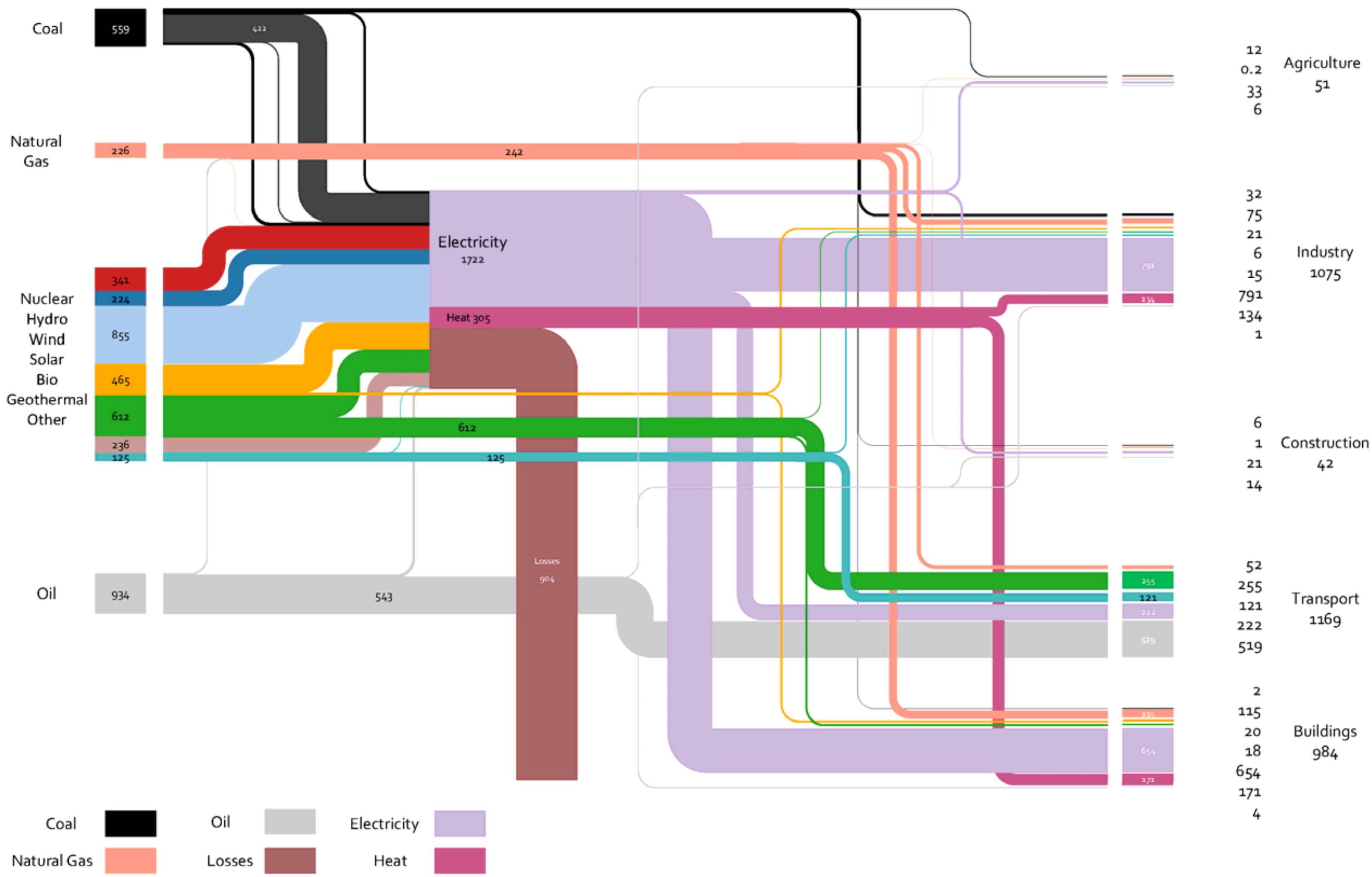
CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

2050 Below 2 °C Scenario

Further enforced in the Below 2 °C Scenario

- Higher RE share
- Less coal
- Higher electrification

2050 Energy flow chart Below 2°C（Mtce）

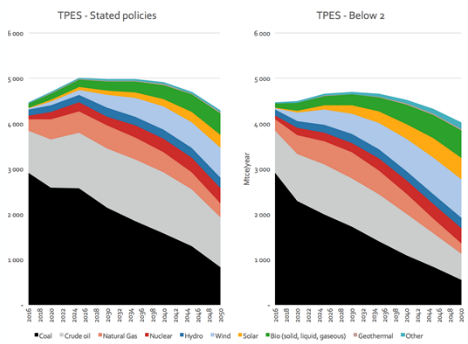


CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

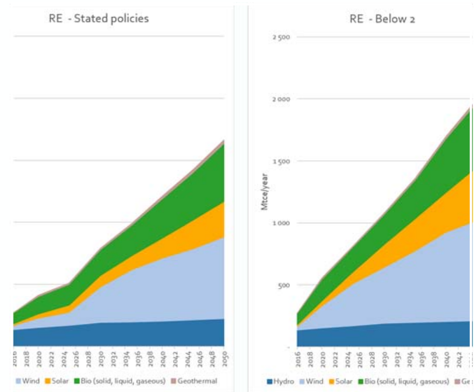
Same trends in the two scenarios

- The two scenarios have **the same long term development trends**
  - Coal phase out
  - Primary energy demand peak around 2030
  - Strong growth in RE
  - Decarbonisation
  - Similar power costs in 2050
- Long term development driven by market conditions – RE competitive with fossil fuels when carbon pricing is included

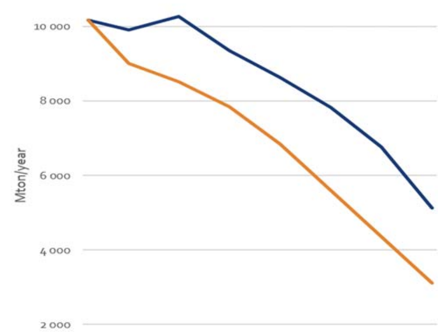
Primary energy consumption



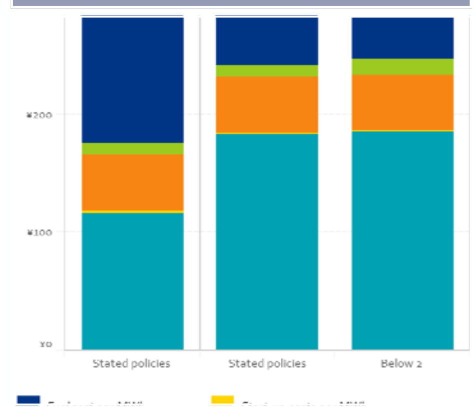
RE development



CO2 emission



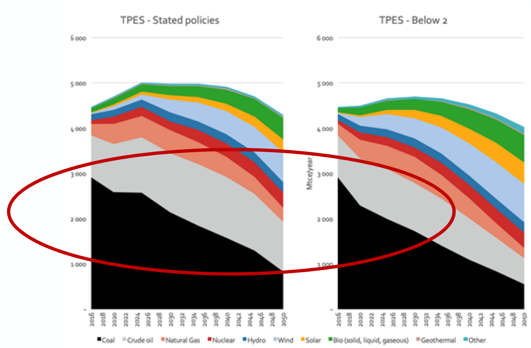
2050 Power cost



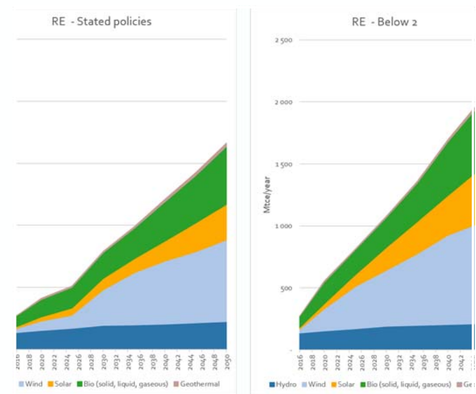
Same trends in the two scenarios

- Main difference
  - CO_2 constraints push for rapid RE deployment and fossil fuel phase-out in B2DC

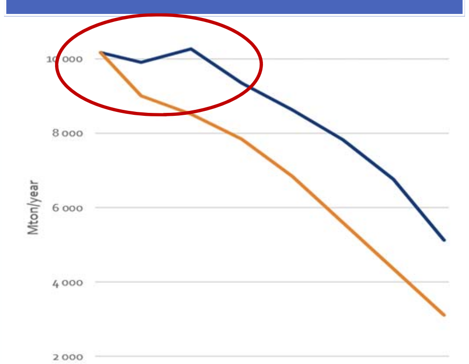
Primary energy consumption



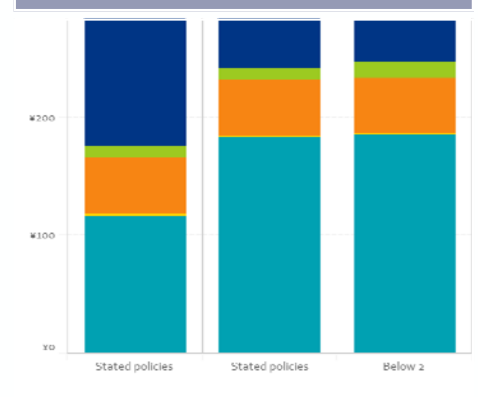
RE development



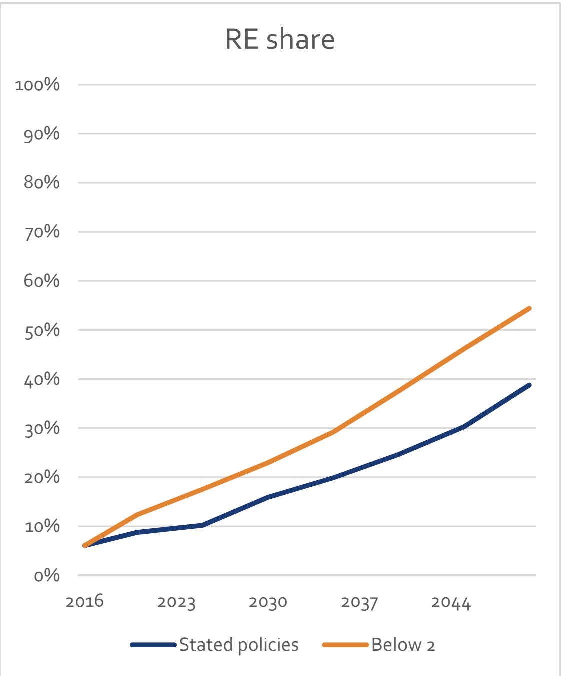
CO2 emission

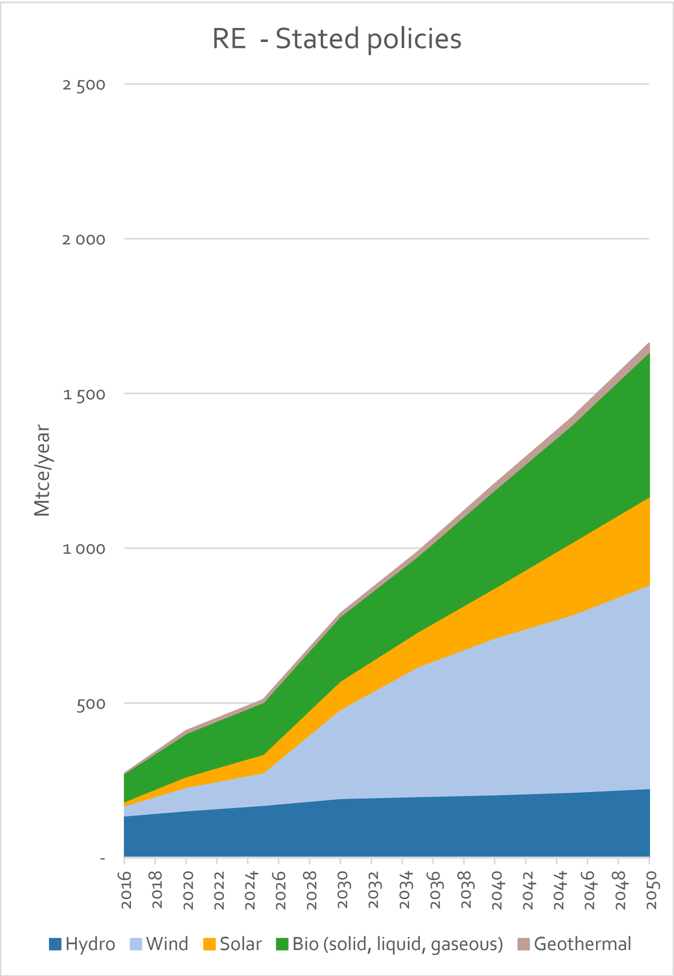


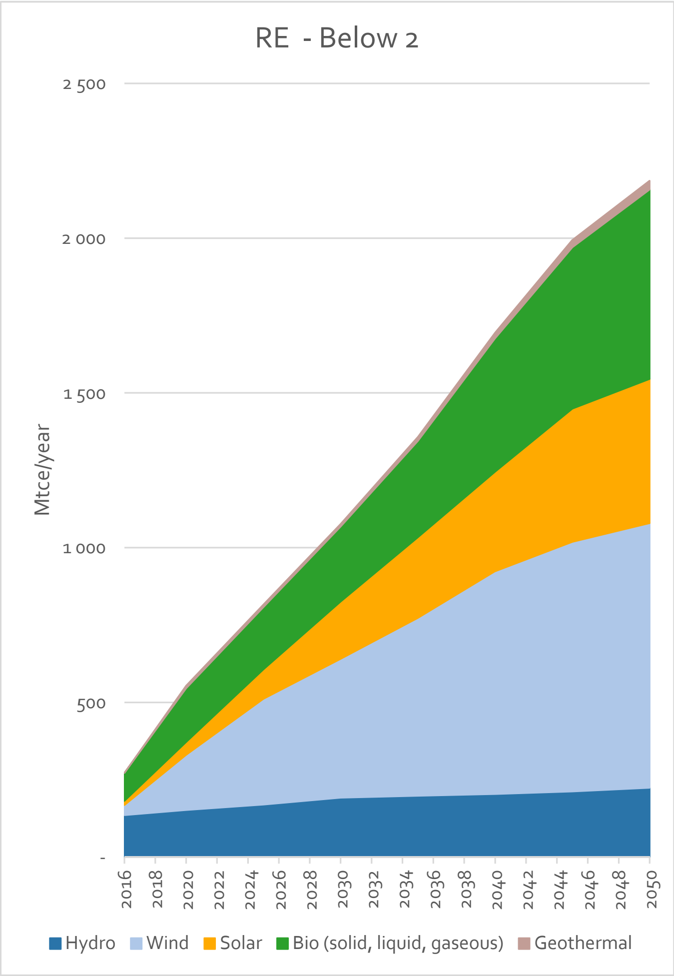
2050 Power cost



RE becomes the energy system back-bone

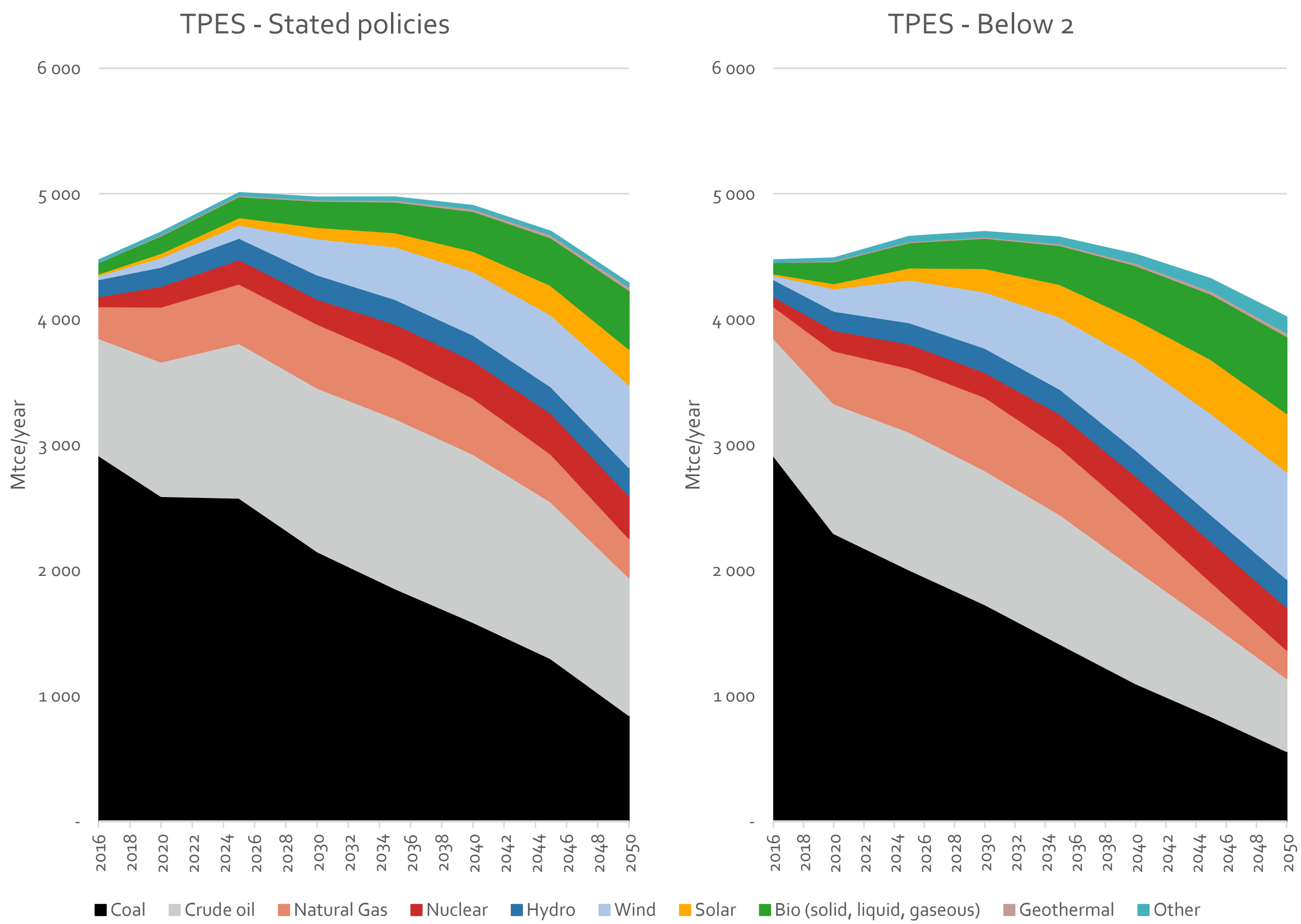






Primary energy demand

- Primary energy demand peaks around 2030 in both scenarios
- Coal phase out in both scenarios – biggest and quickest in the Below 2°C Scenario
- Oil reduction in Below 2°C Scenario
- Natural gas will continue to have a minor role in the energy supply



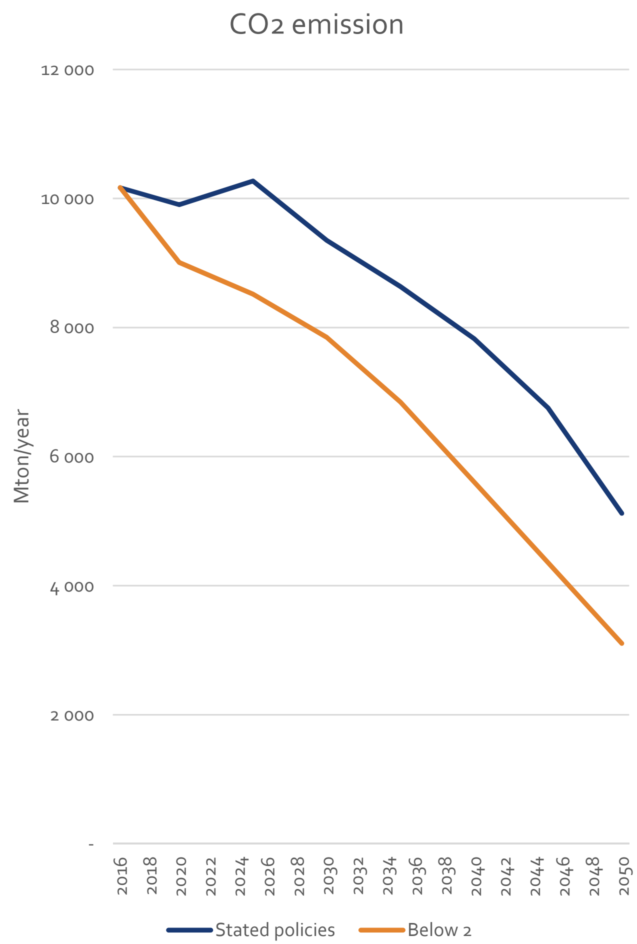
CO_2 reduction

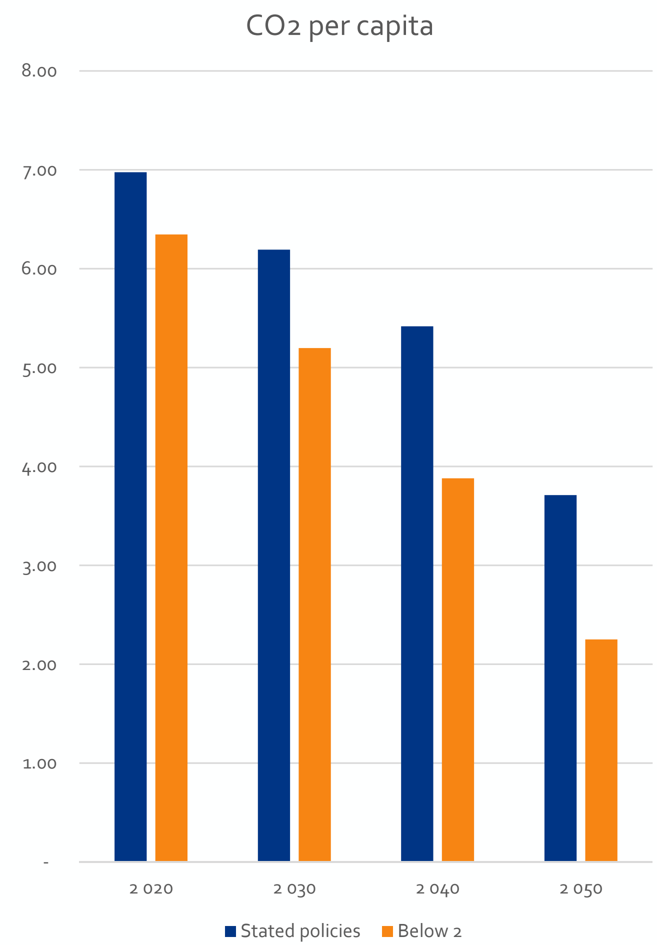
Stated Policy Scenario

- Peak before 2030 and rapid decline thereafter
- After 2030 – CO_2 reduction driven by market forces. RE replaces fossil fuel for economic reason, when carbon pricing is in place
- Stated Policy Scenario do not comply with the Paris agreement target

Below 2°C Scenario

- Carbon constraint important driver for the development
- Quick CO_2 reduction necessary to comply with Paris agreement

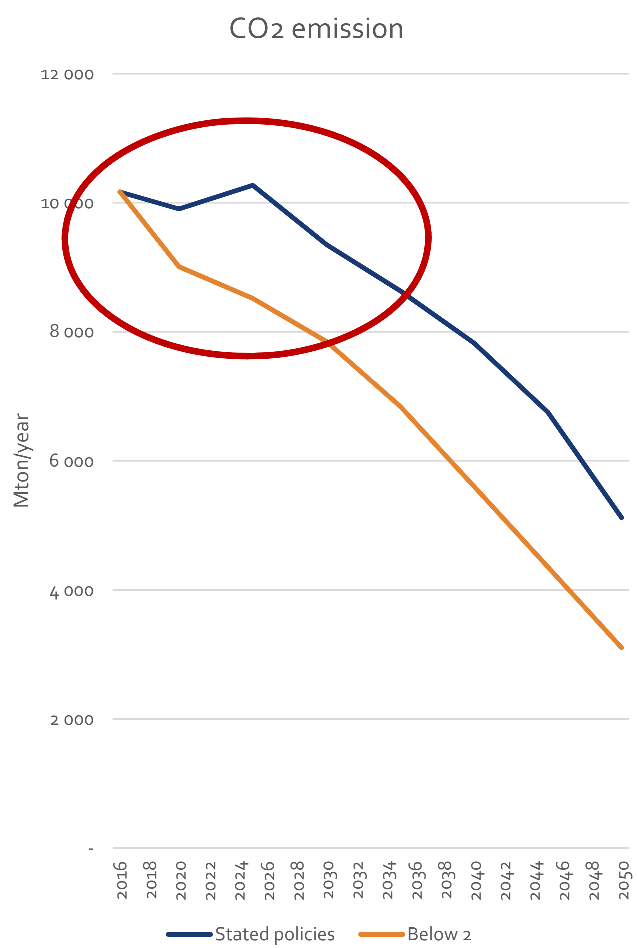


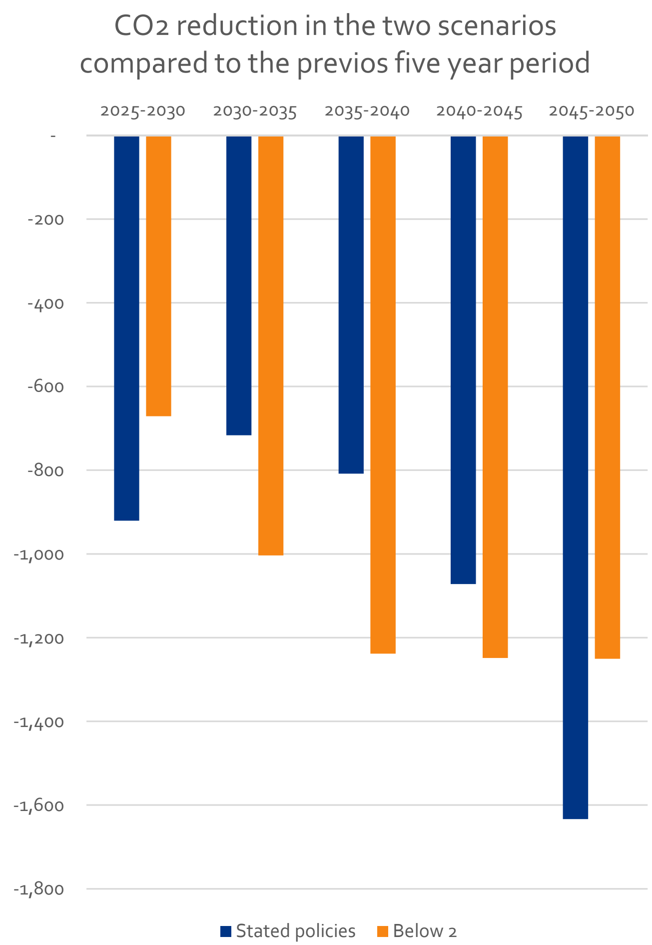


CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

Fast action needed for CO2 reduction

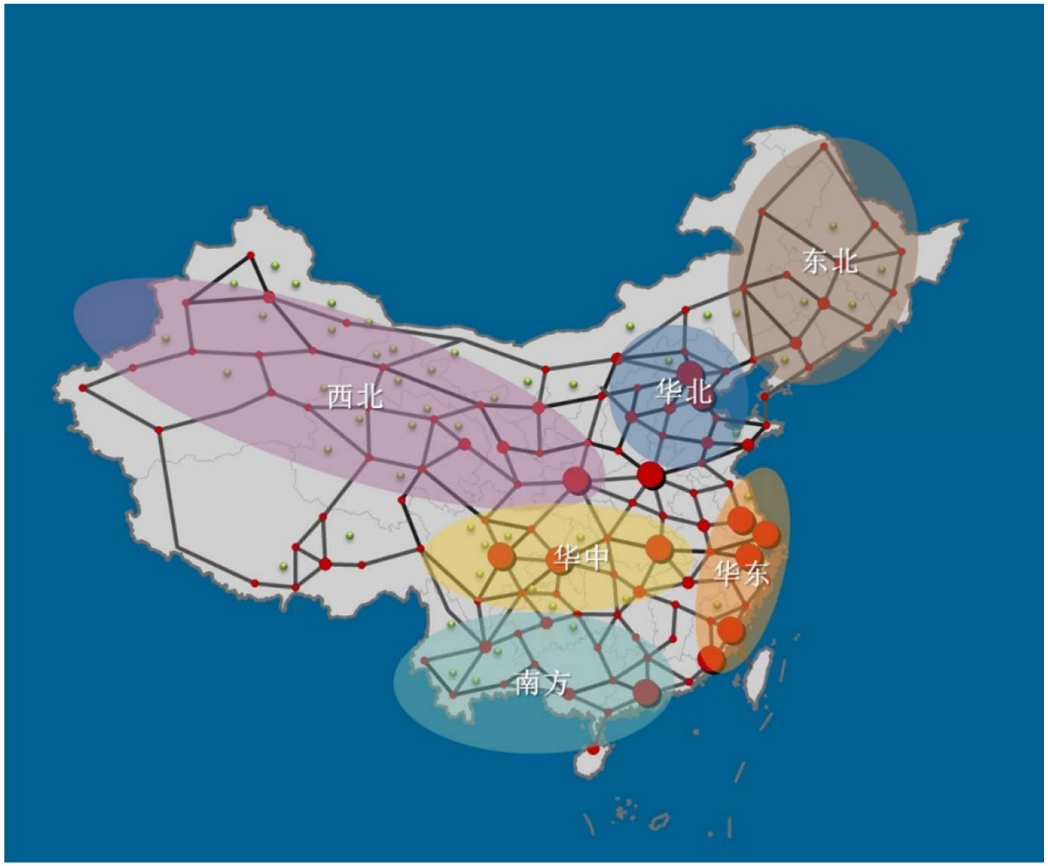
- After 2030 RE will substitute coal and oil for economic reasons, if the carbon pricing is in place
- To ensure compliance with the Paris agreement – strong support to RE deployment needed on national and local level
- The Below 2°C Scenario gives a more smooth transition than the Stated Policies Scenario and gives more stable conditions for the RE industry
- However, short-term transition is ambitious and require strong measures



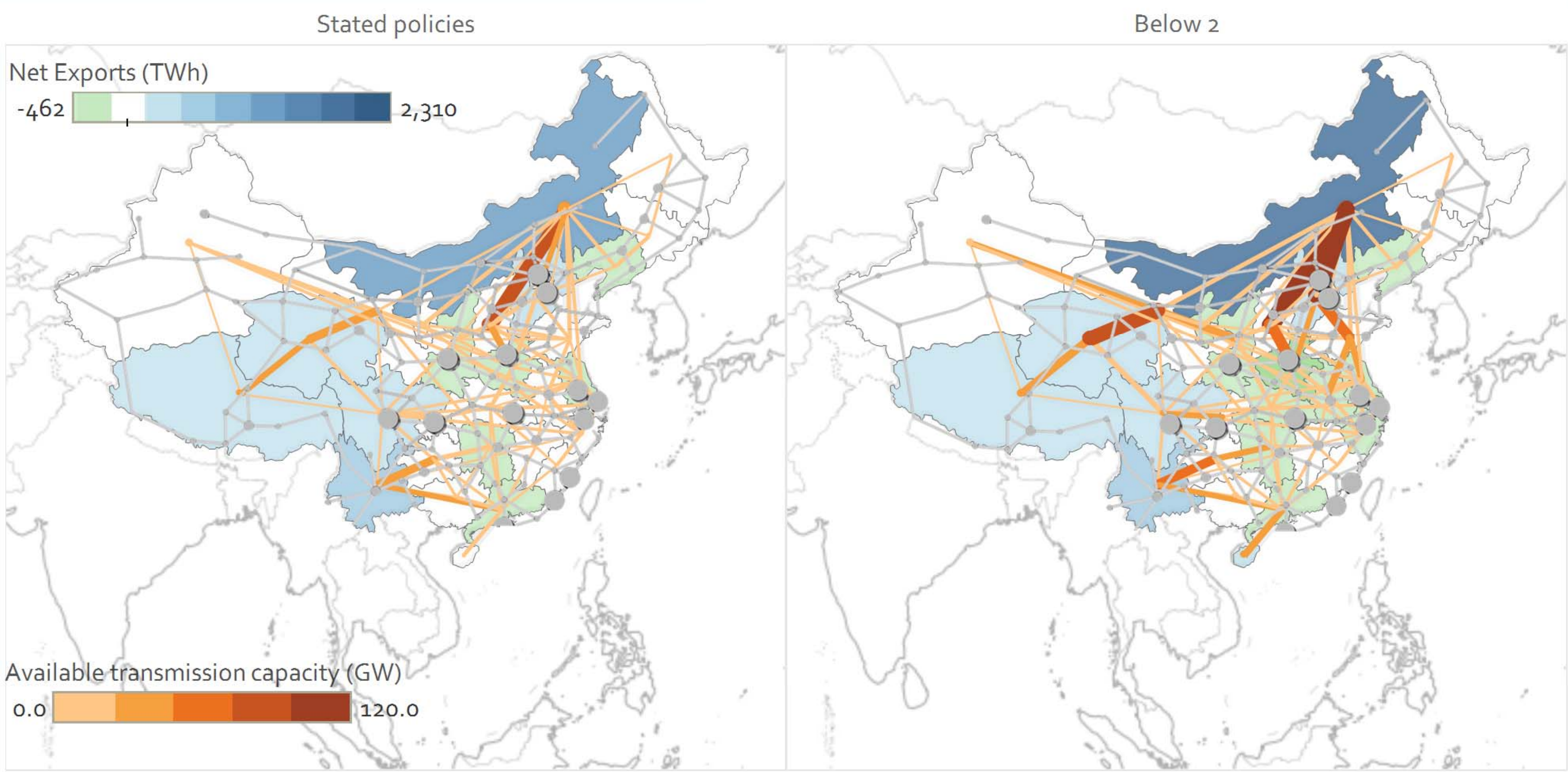


Grid development

- The long-term grid development strategy should be based on province-to-province interconnectors combined into regional grids
- Grid planning should take into account the power market development and flexible, market-based dispatch of the transmission lines



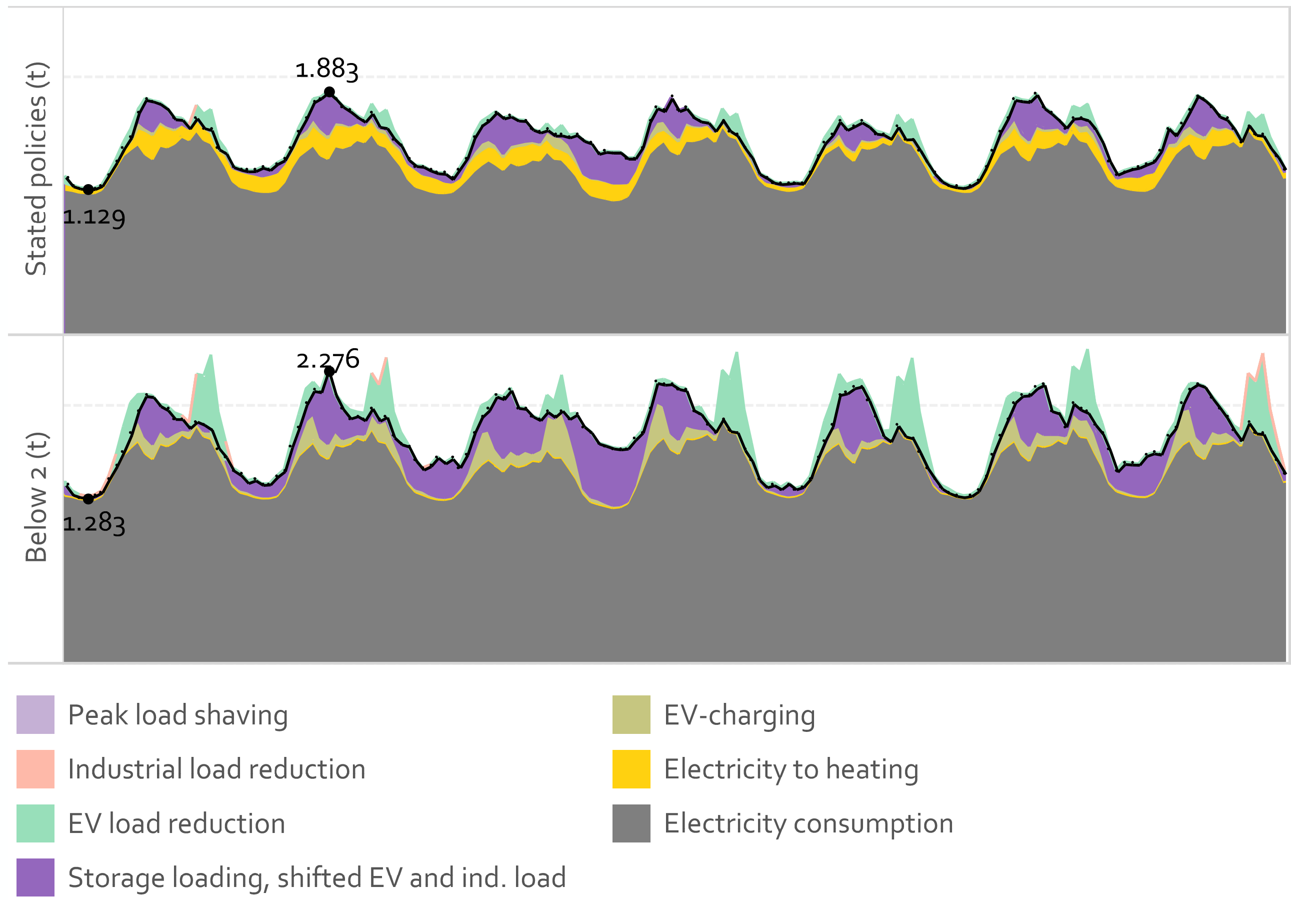
The power grid essential as integrator and distributer of RE in 2050



Large amount of RE can be integrated by enhancing flexibility

Demand side measures

- Peak load shaving
- Industrial load shifting
- EV smart charging
- EV charging
- Storage loading
- Electricity to heat

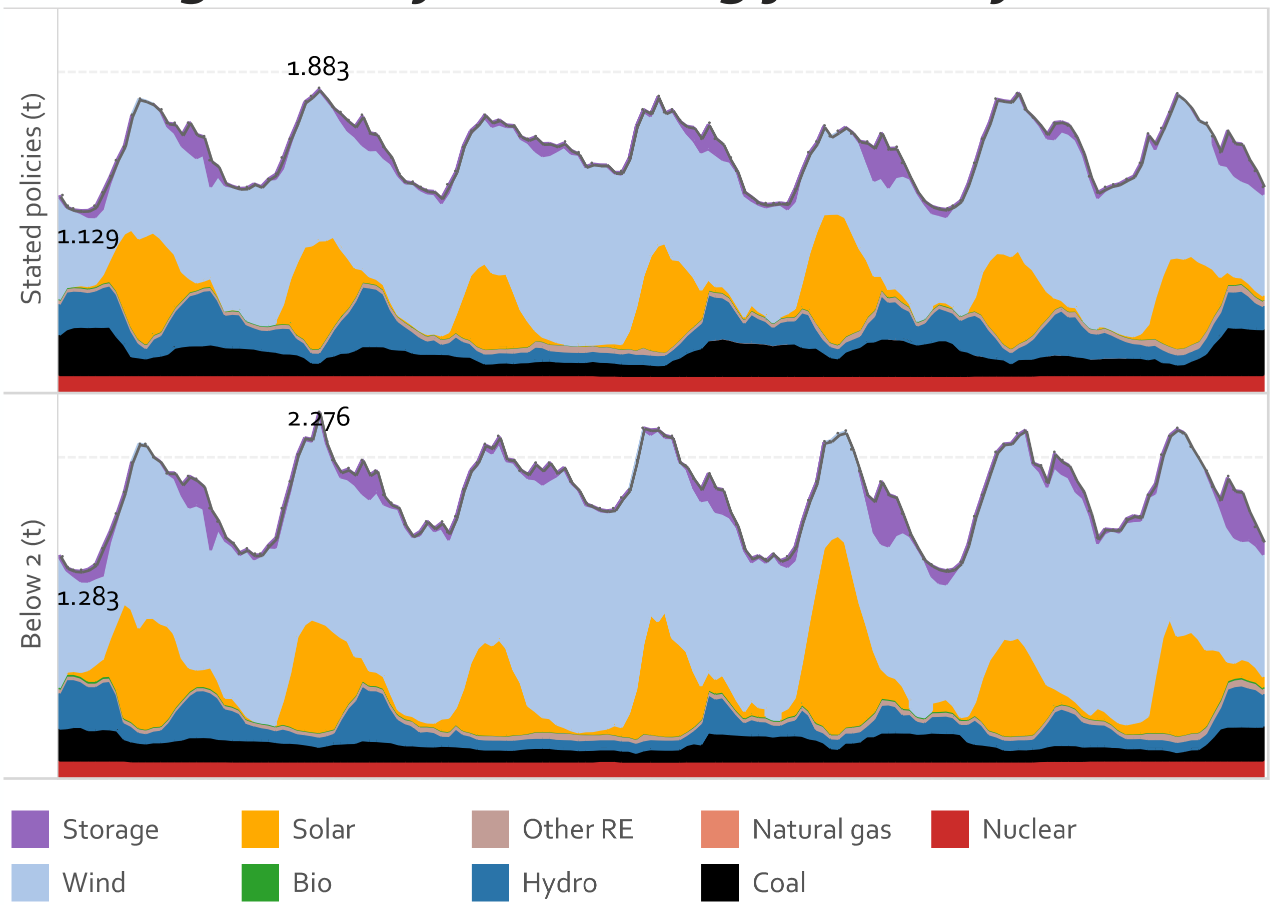


CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

Large amount of RE can be integrated by enhancing flexibility

Supply side measures

- Flexible thermal power plants
- Flexible hydro
- Storage discharging
- Market value based VRE remuneration incentives

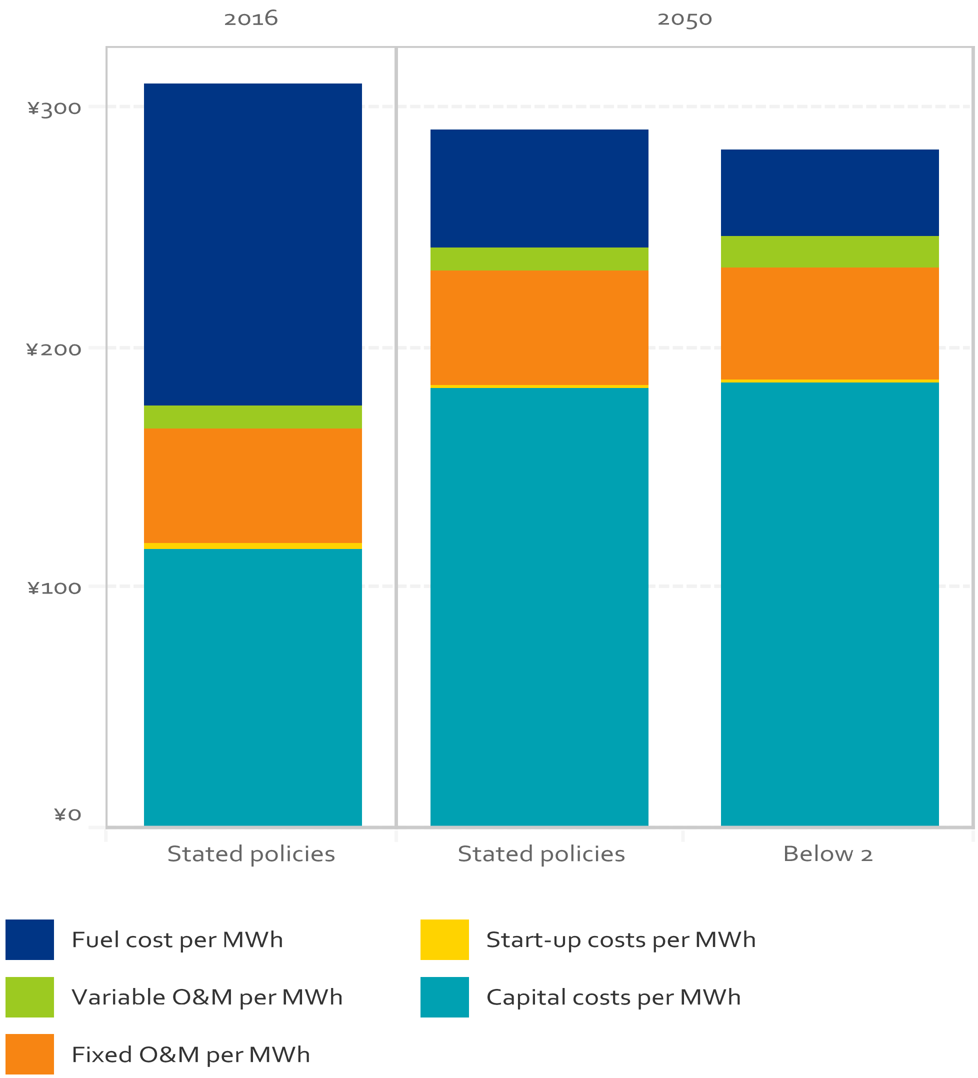


Power cost

(transmission cost not included)

Long term benefits

- Cost of power production shift from fuel costs to capital cost
- Both scenarios have lower power cost in 2050 compared with today's prices (in fixed prices)
- The huge investments in RE technologies will give higher power cost in the short run, but also benefits in form of job creation, RE industry development and better environment



Wrap-up

The Stated Policies Scenario and the Below 2 °C Scenario have the same long-term development trends – high RE share, coal phase-out, high energy efficiency

Todays policy strategies are well-suited for the energy transition – carbon pricing, promotion of renewable energy to achieve cost reductions, introduction of power markets. Strong and efficient implementation of the strategies are needed, on central level as well as local level

The Paris agreement puts pressure on the short-term energy transition. A rapid transition from coal and oil to non-fossil fuels with put China on the right track for compliance with the agreement

POLICY RECOMMENTATIONS

CHINA NATIONAL RENEWABLE ENERGY CENTRE

RE and non-fossil fuel targets

- The 13th five-year plans RE capacity targets for 2020 are minimum targets. We recommend that the RE development should go beyond these targets: Solar from 110 GW to 200 GW, wind from 210 GW to 350 GW, bioenergy from 15 GW to 30 GW – a total of 500 GW.
- The non-fossil energy share could go beyond target of 50% by 2050. Considering the Below 2°C temperature control target, the development targets need to be further enhanced.

Increase efforts to reduce coal consumption

- Stop for approval of new coal power plants
- Reduce the coal share of the primary energy consumption from 64% to 33% in 2030
- Requirements for coal power plant flexibility and gradually removal of the planned full-load hours
- The provinces which economy heavily depend on coal, must immediately develop a coal transition plan away from coal

Power sector reform

- accelerate the provincial and regional market pilots, establishing competitive wholesale market and retail market
- Include dispatch of interconnectors in the market pilots by removal of interprovincial trade barriers and by uniform transparent market rules
- Prevent lock-in of coal power production via bilateral trading contracts
- Clear road map for next step development of the power market in China

ETS system

- Strong focus on the viability of the National market – avoid pitfalls from grandfathering and new policy traps
- Set a floor price for CO_2 which create impact on investment decisions

From incentives to market driven deployment

- Increase the use of competitive auctions to lower FIT for large-scale wind and solar projects (moved first)
- With the gradual establishment of competitive power markets after 2020, wind power and solar power should be integrated into the market
- the feed-in tariff could be replaced by a feed-in premium(FIP),or Contract for Difference(CfD) when efficient whole sale markets are in place
- Based on the establishment of a voluntary trading market for renewable energy power certificates in 2017, a mandatory (electricity side) renewable energy power quota and green certificate market should be established by 2020, increasing the quota requirement year by year

CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE

	2017		2020		2025	2030
Competitive Power Market	In Progress			Fully In Place		
Renewable Power Green Certificate Voluntary Market	Kick Off		Mature			
Renewable Power Green Certificate Mandated Market		Kick Off	Mature			
ETS	Kick Off		Mature			
On-shore Wind	FIT With FIT Level Decline		FIT To FIP	FIP With Premium Decline	Parity	
Offshore Wind	Stable FIT			FIT To FIP After Accumulated Capacity Over 10GW	FIP With Premium Decline	Parity
Large PV	FIT With FIT Level Decline		FIT To FIP	FIP With Premium Decline	Parity	
Distributed PV	FIP With Premium Decline			Parity For Other Distributed PV	parity For Residential Distributed PV	
CSP	Stable FIT			FIT To FIP After Accumulated Capacity Over 10GW	FIP With Premium Decline	Parity
Biomass Power	FIT		FIT	To FIP With Premium Decline	Parity	
Geothermal Power, Ocean Power etc.	Pilot Project Tariff Or FIT				FIT/FIP With Premium Decline	

THANK YOU FOR YOUR ATTENTION

CNREC
CHINA NATIONAL RENEWABLE ENERGY CENTRE